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(54) SURFACE ACOUSTIC WAVE RESONATOR

(57)Abstract:

PURPOSE: To provide a small-sized small-capacitance surface acoustic wave resonator by arranging an interdigital transducer with a metal whose specific gravity is large on the surface of a rotation Y cut LiTaO3 piezoelectric substrate and exciting Love wave type surface acoustic waves in the direction of an X axis. CONSTITUTION: The interdigital transducer 2 provided with terminal 4 and 4' is provided on the surface of the rotation Y cut LiTaO3 piezoelectric substrate 1 cut by a prescribed angle within a range where a rotation angle from a Y axis is -10° to +50% on a Y-Z plane with the Y axis as a normal line. The electrode of the interdigital transducer 2 is not an electrode having a uniform thin film and is sufficiently thickened by the metal whose specific gravity is large such as gold,

platinum and silver, so that an effect equivalent to the uniform film can be obtained and pseudo surface acoustic waves can be transformed to the Love wave type surface acoustic waves. Thus, a Love wave type surface acoustic wave resonator much smaller than the surface acoustic wave resonator utilizing a LiTaO3 piezoelectric substrate for not largely depending on the accuracy of cut rotation angle whose capacitance ratio is small can be obtained.

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CLAIMS

[Claim(s)]

[Claim 1] Rotation Y cut LiTaO3 which made the Y-axis the normal and was cut at an angle of predetermined [of the range whose angles of rotation from a Y-axis are -10 degrees thru/or +50 degrees on a Y-Z flat surface] Surface acoustic wave resonator constituted so that the blind-like transducer formed with the metal with large specific gravity on the front face of a piezo-electric substrate might be arranged and a Love wave mold surface acoustic wave might be excited by X shaft orientations of said piezo-electric substrate.

[Claim 2] Rotation Y cut LiTaO3 which made the Y-axis the normal and was cut at an angle of predetermined [of the range whose angles of rotation from a Y-axis are -10 degrees thru/or +50 degrees on a Y-Z flat surface] On the front face of a piezo-electric substrate The blind-like converter formed with the metal with large specific gravity and the grating reflector formed on the surface-wave propagation path of the both sides of this blind-like converter with the metal with the same heavy specific gravity as this blind-like converter are arranged. The surface acoustic wave resonator constituted so that a Love wave mold surface acoustic wave might be excited by X shaft orientations of said piezo-electric substrate.

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the energy ****** type surface acoustic wave resonator used for the voltage controlled oscillator (VCO) of electronic equipment, especially communication equipment as a resonant element.

[0002]

[Description of the Prior Art] When using a frequency synthesizer for a transmitter, the large thing of the frequency adjustable range is required of a voltage controlled oscillator (VCO). Therefore, when using a surface acoustic wave resonator as a resonant element of a voltage controlled oscillator, it is required that a capacity factor (value proportional to the inverse number of the difference of resonance frequency and antiresonant frequency) should be small to a surface acoustic wave resonator, and an electromechanical coupling coefficient (k2) should be large. The energy ****** type surface acoustic wave resonator (it is written as a SAW resonator below) using the piezo-electric substrate of lithium tantalate (LiTaO3) as a surface acoustic wave resonator which meets such a demand is mentioned. The SAW resonator using the piezo-electric substrate of the conventional lithium tantalate (LiTaO3) has two kinds of things as follows. One of them is Rayleigh (Rayleigh) who exists on the piezo-electric substrate of the direction propagation of X cut-112-degree rotation Y. Using a wave type

surface wave, another uses the false surface acoustic wave (leek wave type surface wave) which exists on the piezo-electric substrate of the direction propagation of 36 degreeY cut-X. The SAW resonator using the surface wave of a Rayleigh wave mold is an electromechanical coupling coefficient k2. Since it is about 0.7% comparatively small, when a SAW resonator is constituted, a capacity factor becomes about 250 and is not made not much small. coupling coefficient k2 since it is small -- the electrode number of a grating reflector, and the electrode of IDT -- it is necessary to make [many] a logarithm and disadvantageous for a miniaturization. On the other hand, the SAW resonator using a false surface acoustic wave is the 36 degreeY cut-X propagation LiTaO3 whose cutting angle of rotation is 36 degrees although the propagation magnitude of attenuation is generally large since it is the leek (Leaky) wave spread while emitting a bulk wave into a piezo-electric substrate. When it is a piezo-electric substrate, the propagation magnitude of attenuation is set to about 0, and it is a coupling coefficient k2. With 4.7%, since it is comparatively large, it is put in practical use and used. However, the wave of this form has the fault which produces attenuation, when a cut angle of rotation shifts from 36 degrees, since it is essentially a leek wave.

[0003] Drawing 3 (A) is LiTaO3. It is the property Fig. of a surface wave rate to the cutting angle of rotation of a substrate. As shown in drawing 3 (B), an axis of abscissa shows the cutting angle of rotation theta from the Y-axis within a Y-Z side, and a surface wave is spread to X shaft orientations. As shown in drawing 3 , it is the rotation Y cut LiTaO3. It is known that the Rayleigh wave and the false surface acoustic wave with a quick surface wave rate (leek wave) which were shown with the broken line with a slow surface wave rate exist on a piezo-electric substrate. Moreover, electromechanical coupling coefficient k2 It defines as a degree type.

[Equation 1]

$$k^2 = \frac{2\,(V_f - V_s)}{V_f}$$

however -- Vf : Surface wave rate Vm of surface freedom (Free Surface) : Surface wave rate [0004] of a surface short circuit (Metalized Surface) [Problem(s) to be Solved by the Invention] An upper type to electromechanical coupling coefficient k2 Surface wave rate Vf of surface freedom Surface wave rate Vm of a surface short circuit The value becomes large, so that a difference is large. Therefore, in the case of a Rayleigh wave, since both have almost lapped, it is a coupling coefficient k2. It is very small. On the other hand, a false surface acoustic wave has the largest difference of a surface wave rate, when a cutting angle of rotation is 0 degree (it is also called a common-name Y cut), and they are about 1.3 times in case cutting angle of rotation is 36 degrees (36 degree Y cut of common names). That is, it compares with 36-degree Y cut, and the direction of 0-degree Y cut is k2. It turns out that a capacity factor can be greatly made small. However, since a false surface acoustic wave is a leek wave, although, as for near the 36 degreeY, the propagation magnitude of attenuation of a surface wave is set to 0, there is a trouble that it cannot use if the precision of a cutting angle of rotation is a problem, makes an angle of rotation 0 degree, and it becomes [the propagation magnitude of attenuation] large and remains as it is. Moreover, LiTaO3 The Love wave mold surface acoustic wave resonator used as a piezo-electric substrate is not put in practical use yet. The purpose of this invention is conventional above LiTaO3. It is still smaller than the surface acoustic wave resonator using a piezo-electric substrate, and is in offering the surface acoustic wave resonator of the Love wave mold for which a capacity factor does not depend greatly [it is small and] for the precision of a cutting angle of rotation.

[0005]

[Means for Solving the Problem] The surface acoustic wave resonator of this invention is the rotation Y cut LiTaO3 which made the Y-axis the normal and was cut at an angle of predetermined [of the range whose angles of rotation from a Y-axis are -10 degrees thru/or +50 degrees on a Y-Z flat surface]. On the front

face of a piezo-electric substrate The blind-like transducer formed with the metal with large specific gravity is arranged, and what was constituted so that a Love wave mold surface acoustic wave might be excited by X shaft orientations of said piezo-electric substrate is considered as a basic configuration. Furthermore, this blind-like converter and the grating reflector formed with the metal with the same large specific gravity are arranged on the surface-wave propagation path of the both sides of said blind-like converter, and it is characterized by constituting so that a Love wave mold surface acoustic wave may be excited by X shaft orientations of said piezo-electric substrate.

[0006] That is, since the Love wave mold surface acoustic wave resonator which was not realized conventionally is put in practical use, it is LiTaO3. It is a coupling coefficient k2 by making it later than the late transverse wave which the late heavy matter of acoustic velocity is made to adhere, and a surface-acoustic-waves rate is reduced on a piezo-electric substrate, and is shown in drawing 3 . It changes into almost remaining as it is or a Love wave mold surface wave without the propagation attenuation of a false surface acoustic wave more than by it. even if it is not the electrode of a uniform thin film about the electrode of a blind-like converter (IDT:Interdigital Transducer) at this time, effectiveness equivalent to the uniform film (however, thickness -- equivalent -- about -- regarded as one half) is acquired equivalent by making it sufficiently thick with a metal with the large specific gravity of gold (Au), platinum (Pt), silver (Ag), etc., and a false surface acoustic wave can be changed into a Love wave mold surface wave. Furthermore, it is the 36 degreeY cut-X propagation LiTaO3 so that more clearly than drawing 3 , if the range of the cutting include angle of a rotation Y cut is -10 degrees - +50 degrees (drawing 3 170 degrees - 180 " and 0 degree - 50 degrees). Equivalent to a case, or coupling coefficient k2 beyond it There is an advantage that being obtained is clear and the effect to the propagation magnitude of attenuation of the precision of a rotation cut angle is lost.

[0007]

[Example] Drawing 1 is the basic block diagram showing the 1st example of this

invention, and drawing 2 is the block diagram showing the 2nd example. The 1st example of drawing 1 R> 1 is the surface acoustic wave resonator constituted only by IDT2 to which the range of the cutting include angle of a rotation Y cut shows the basic configuration which arranged the terminal 4 and the blind-like converter (IDT) 2 which has 4' on the -10 degrees - +50 degrees front face of the piezo-electric substrate (drawing 3 170 degrees - 180 " and 0 degree - 50 degrees) 1, and made [many / comparatively] the logarithm of IDT2. Moreover, the 2nd example of drawing 2 is the Love wave mold surface acoustic wave resonator of the structure which has arranged the grating reflector 3 which becomes the both sides of IDT2 of the basic configuration of drawing 1 from the electrode material of the same heavy metal as IDT2. The thing of this configuration is the direction propagation LiTaO3 of 36 degreeY cut-X. It compares with the conventional false surface acoustic wave resonator which formed the same electrode structure as drawing 2 with light metals, such as aluminum, on the piezo-electric substrate, and is an electromechanical coupling coefficient k2. Since only a large part can lessen the number of the electrode finger of a reflector 3 (1/2 or less), while a miniaturization becomes possible, the small surface acoustic wave resonator of a capacity factor is realizable. Electromechanical coupling coefficient k2 As an actual measurement, about 11% or more of value was acquired compared with 4.7 conventional%. Although the above example explained the basic configuration of only IDT2 shown in drawing 1 , and the configuration which has arranged the grating reflector 3 on both sides of IDT2 shown in drawing 2 , in order to improve a spurious response, it cannot be overemphasized that this invention is applicable also about the surface acoustic wave resonator which performed weighting from which **** is prepared in the electrode finger of IDT2, and the whole becomes a rhombus.

[0008]

[Effect of the Invention] By carrying out this invention, compared with the surface acoustic wave resonator using the conventional false surface acoustic wave, a chip size can be made small, and a miniaturization can be attained. Furthermore,

since a capacity factor can be made small, when it uses for a voltage controlled oscillator etc., since broadband-ization of the frequency adjustable range can be attained, practical effectiveness is very large.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram showing the 1st example of this invention.

[Drawing 2] It is the block diagram showing the 2nd example of this invention.

[Drawing 3] Rotation Y cut LiTaO3 It is the related Fig. of a rotation cut angle and a surface wave rate in a substrate.

[Description of Notations]

1 Piezo-electric Substrate

2 Blind-like Converter (IDT)

3 Grating Reflector

4 4' Terminal

[Translation done.]

* NOTICES *

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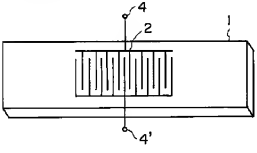
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

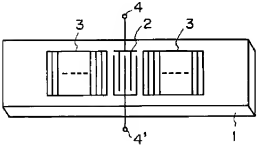
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]

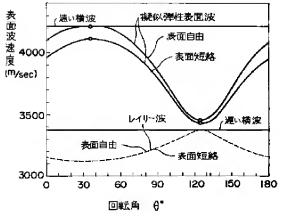


[Drawing 2]

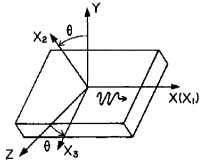


[Drawing 3]

(A)



(B)



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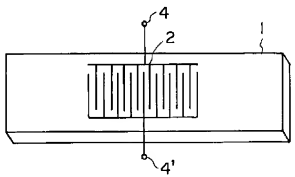
最終頁に続く

(54)【発明の名称】　弾性表面波共振子

(57)【要約】
【目的】回転ＹカットＬｉＴａＯ₃の圧電基板を用いてラブ波型弾性表面波共振子を実現し、小形化と容量比の小さい弾性表面波共振子を実用化することを目的とする。
【構成】Ｙ軸からの切断回転角が－１０°～＋５０°の範囲の回転ＹカットＬｉＴａＯ₃圧電基板１の表面上に、比重の大きい金属で形成された多数の交差指を有するすだれ状変換器２を配置し、基板のＸ軸方向にラブ波型弾性表面波を励起せしめるように構成したことを特徴とする。



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【特許請求の範囲】

【請求項1】　Y軸を法線としY－Z平面上でY軸からの回転角が－10°乃至＋50°の範囲の所定の角度で切断された回転YカットLiTaO3圧電基板の表面上に、比重の大きい金属で形成されたすだれ状変換器が配設され、前記圧電基板のX軸方向にラブ波型弾性表面波が励起されるように構成した弾性表面波共振子。

【請求項2】　Y軸を法線としY－Z平面上でY軸からの回転角が－10°乃至＋50°の範囲の所定の角度で切断された回転YカットLiTaO3圧電基板の表面上に、比重の大きい金属で形成されたすだれ状変換器と該すだれ状変換器の両側の表面波伝搬路上に該すだれ状変換器と同じ比重の重い金属で形成されたグレーティング反射器とが配設され、前記圧電基板のX軸方向にラブ波型弾性表面波が励起されるように構成した弾性表面波共振子。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、電子機器、特に通信機器の電圧制御発振器（VCO）に共振素子として用いられるエネルギ閉じ込め型弾性表面波共振子に関するものである。

【0002】

【従来の技術】通信機に周波数シンセサイザを利用する場合、電圧制御発振器（VCO）に周波数可変範囲の広いことが要求される。従って電圧制御発振器の共振素子として弾性表面波共振子を用いる場合には、弾性表面波共振子に容量比（共振周波数と反共振周波数の差の逆数に比例する値）が小さく、かつ電気機械結合係数（k^2）の大きいことが要求される。このような要求に応える弾性表面波共振子として、タンタル酸リチウム（LiTaO3）の圧電基板を用いたエネルギ閉じ込め型弾性表面波共振子（以下SAW共振子と略記する）が挙げられる。従来のタンタル酸リチウム（LiTaO3）の圧電基板を用いたSAW共振子は次の2種類のものがある。その1つは、Xカット－112°回転Y方向伝搬の圧電基板上に存在するレイリー（Rayleigh）波型の表面波を利用したものであり、もう1つは、36°YカットーX方向伝搬の圧電基板上に存在する擬似弾性表面波（リーキ波型の表面波）を利用したものである。レイリー波型の表面波を利用したSAW共振子は、電気機械結合係数k^2が比較的小さく0.7%程度であるためSAW共振子を構成した場合には容量比が250程度となりあまり小さくできない。結合係数k^2が小さいためグレーティング反射器の電極本数やIDTの電極対数を多くする必要があり小型化には不利である。一方、擬似弾性表面波を利用したSAW共振子は、圧電基板中にバルク波を放射しながら伝搬するリーキ（Leaky）波であるため一般に伝搬減衰量が大きいが、切断回転角が36°の36°Yカット－X伝搬LiTaO3の圧電基板の

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場合は伝搬減衰量がほぼ0になり、結合係数k^2も4.7%と比較的大きいので実用化されて用いられている。しかしながら、この形の波は本質的にリーキ波であるためカット回転角が36°からずれると減衰を生ずる欠点がある。

【0003】図3（A）はLiTaO3基板の切断回転角に対する表面波速度の特性図である。図3（B）に示すように、横軸はY－Z面内のY軸からの切断回転角θを示し、表面波はX軸方向に伝搬する。図3に示すように、回転YカットLiTaO3圧電基板上には、表面波速度の遅い破線で示したレイリー波と表面波速度の速い擬似弾性表面波（リーキ波）が存在することが知られている。また、電気機械結合係数k^2は次式で定義される。

【数1】

$$k^2 = \frac{2(V_f - V_a)}{V_f}$$

但し、V_f：表面自由（Free Surface）の表面波速度

V_a：表面短絡（Metalized Surface）の表面波速度

【0004】

【発明が解決しようとする課題】上式から、電気機械結合係数k^2は、表面自由の表面波速度V_fと表面短絡の表面波速度V_aの差が大きい程その値は大きくなる。従ってレイリー波の場合はほとんど同者が重なっているため結合係数k^2は極めて小さい。一方擬似弾性表面波は切断回転角が0°（通称Y板ともいう）の場合に表面波速度の差が最も大きく、切断回転角度が36°（通称36°Y板）の場合の約1.3倍である。すなわち36°Y板に比べ0°Y板の方がk^2が大きく容量比を小さくできることがわかる。しかしながら擬似弾性表面波はリーキ波であるため、36°Y近傍は表面波の伝搬減衰量が0となるが、切断回転角の精度が問題であり、回転角を0°にすると伝搬減衰量が大きくなりそのままでは実用することはできないという問題点がある。また、LiTaO3を圧電基板として利用したラブ波型弾性表面波共振子はまだ実用化されていない。本発明の目的は、上記の従来のLiTaO3圧電基板を利用した弾性表面波共振子よりさらに小形で、容量比が小さく切断回転角の精度に大きく依存しないラブ波型の弾性表面波共振子を提供することにある。

【0005】

【課題を解決するための手段】本発明の弾性表面波共振子は、Y軸を法線としY－Z平面上でY軸からの回転角が－10°乃至＋50°の範囲の所定の角度で切断された回転YカットLiTaO3圧電基板の表面上に、比重の大きい金属で形成されたすだれ状変換器が配設され、前記圧電基板のX軸方向にラブ波型弾性表面波が励起されるように構成したものを基本構成とし、さらに、前記すだれ状変換器の両側の表面波伝搬路上に該すだれ状変

換器と同じ比重の大きい金属で形成されたグレーティング反射器が配設され、前記圧電基板のX軸方向にラブ波型弾性表面波が励起されるように構成したことを特徴とするものである。

【0006】すなわち、従来実現されていなかったラブ波型弾性表面波共振子を実用化するために、$LiTaO_3$ 圧電基板上に音速の遅い重い物質を付着させて表面弾性波速度を低下させ、図3に示す遅い横波よりも遅くすることにより結合係数k^2がほぼそのままもしくはそれ以上で擬似弾性表面波を伝搬減衰のないラブ波型表面波に変えたものである。このとき、すだれ状変換器（IDT：Interdigital Transducer）の電極を一様な薄膜の電極でなくても、金（Au），白金（Pt），銀（Ag）等の比重の大きい金属で十分厚くすることで等価的に一様膜（但し膜厚は等価的にほぼ1／2とみなされる）と同等な効果が得られ、擬似弾性表面波をラブ波型表面波に変換することができる。さらに、回転Yカットの切断角度の範囲が－10°～＋50°（図3の170°～180°および0°～50°）であれば、図3より明らかな如く、36°Yカット－X伝搬$LiTaO_3$の場合と同等もしくはそれ以上の結合係数k^2が得られることは明白であり、回転カット角の精度の伝搬減衰量に対する影響がなくなるという利点がある。

【0007】

【実施例】図1は本発明の第1の実施例を示す基本構成図であり、図2は第2の実施例を示す構成図である。図1の第1の実施例は、回転Yカットの切断角度の範囲が－10°～＋50°（図3の170°～180°および0°～50°）の圧電基板1の表面上に端子4，4'を有するすだれ状変換器（IDT）2を配設した基本構成を示すものであり、IDT2の対数を比較的多くしたIDT2のみにより構成した弾性表面波共振子である。また、図2の第2の実施例は、図1の基本構成のIDT2の両側にIDT2と同じ重い金属の電極材料よりなるグレーティング反射器3を配置した構造のラブ波型弾性表面波

共振子である。この構成のものは、36°Yカット－X方向伝搬$LiTaO_3$圧電基板上に図2と同様な電極構造をアルミニウム等の軽い金属で形成した従来の擬似弾性表面波共振子に比べて、電気機械結合係数k^2が大きい分だけ反射器3の電極指の本数を少なく（1／2以下に）することができるため、小型化が可能となると同時に容量比の小さな弾性表面波共振子を実現することができる。電気機械結合係数k^2の実測値としては、従来の4．7％に比べて約11％以上の値が得られた。以上の実施例では、図1に示したIDT2のみの基本構成と、図2に示したIDT2の両側にグレーティング反射器3を配置した構成について説明したが、スプリアス応答を改善するために、IDT2の電極指に断点を設けて全体が菱形になるような重み付けを行った弾性表面波共振子についても本発明を適用することができるのはいうまでもない。

【0008】

【発明の効果】本発明を実施することにより、従来の擬似弾性表面波を利用した弾性表面波共振子に比べてチップサイズを小さくすることができ小型化を図ることができる。さらに、容量比を小さくすることができるため、電圧制御発振器等に利用した場合、周波数可変範囲の広帯域化を図ることができるため実用上の効果は極めて大きい。

【図面の簡単な説明】

【図1】本発明の第1の実施例を示す構成図である。

【図2】本発明の第2の実施例を示す構成図である。

【図3】回転YカットLiTaO₃基板における回転カット角と表面波速度の関係図である。

【符号の説明】

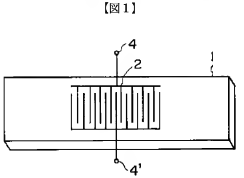
1　圧電基板

2　すだれ状変換器（IDT）

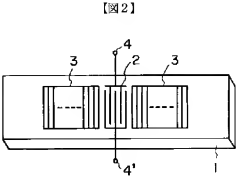
3　グレーティング反射器

4，4'　端子

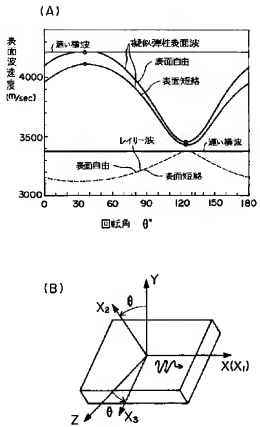
【図1】



【図2】



【図3】



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